THE LIFE HISTORY OF GLOEOTAENIUM

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(WITH PLATE III)

This peculiar alga was first collected by LOITLESBERGER at Ischl, Austria. On the basis of that material, HANSGIRG in 1890 described the genus and only known species, naming it for the collector, *Gloeotaenium Loitlesbergerianum* (1). He characterized the 2 and 4-celled families, with their encircling black bands. The chromatophore was stated to be star-shaped with a large central pyrenoid, and reproduction was limited to the multiplication by separation into two families. He thought the alga to be related to the desmids, and placed it together with *Spirotaenia* in a new family, the Pseudodesmidiaceae, which he conceived to be intermediate between the Desmidiaceae and the Palmellaceae.

In 1891 STOCKMAYER published a more detailed account (2) of the structure and life history, also based on a part of the material collected by LOITLESBERGER. He figures the 2 and 4-celled families and what he took to be a 1-celled individual. His 1-celled form, however, was either a diseased specimen or some other alga. The black band is described as originating by the gelatinization of the next to the outer layer of the mother cell wall in the plane of division. As gelatinization proceeds, the band is pushed inward until it occupies a position between the daughter cells. This process is preceded by the cell division and takes place about the same time that the outer gelatinous wall of the mother cell disappears. Gelatinous "caps" then develop near the poles of the mother cell, and as the second division takes place, these caps elongate in the plane of the second division until they fuse with the black band already formed. Inasmuch as polar "caps" also appeared in the 4-celled families, the author suggested the possibility of 8-celled families.

STOCKMAYER made it evident that the plant is not at all related to the Desmidiaceae, and that the black bands are hardly of sufficient importance to warrant the making of a new family. He con-

cluded that it is most nearly related to *Oocystis* and *Nephrocytium* among the Protococcoideae.

WILLE (**3**) in 1892 included *Gloeotaenium* among the doubtful genera of the desmids in the *Natürlichen Pflanzenfamilien*.

TURNER (**4**) published WALLICH'S notes and figures of the plant from Eastern India in 1892. WEST has expressed some doubt as to the validity of this determination. I do not believe, however, that there can be the slightest doubt about the first four of his figures representing the 2-celled form. The other figures are questionable.

GUTWINSKI (**5**) figured the plant under the name of *Gloeocystis cincta* in his flora of Tarnopol, Austria.

DE TONI (**6**) corrected this name in 1895 and listed the localities in Austria, Italy, and East India in which *Gloeotaenium* had been found.

SCHMIDLE (**7**) reported the plant from Australia in 1896, and WEST (**8**) figured it in 1904 from the Island of Trinidad. In *The green algae of North America* COLLINS (**9**) reprinted one of STOCKMAYER'S figures and placed the genus near *Gloeocystis* among the Chaetophoraceae. Its occurrence, at Charleston, Ill., was reported by the writer (**10**) in 1911. In the recently issued supplement to the *Natürlichen Pflanzenfamilien*, WILLE places the genus next to *Pleurococcus* among the Pleurococcaceae.[1]

Gloeotaenium has been collected at three stations near Charleston, Ill.: the second pond west of the tile factory; Hodgen's pond; and the first pond west of the Big Four Railroad bridge across the Embarras River. All of these ponds are artificial. The first and second are a mile apart, and the third is about four miles east of the other two. Up to the present time the alga has been found only in collections from very definite areas in each of the ponds. In the tile factory pond it is the northeast corner, in Hodgen's pond the northwest corner, and in the Big Four pond the middle of the east side.

In the four years during which collections have been made from these habitats, no specimens have been recognized earlier than the

[1] Since this paper was written, *Gloeotaenium* has been reported by A. B. KLUGH from Colpitts Bay, Ontario (COLLINS, F. S., The green algae of North America, supplementary paper. Tufts Coll. Studies **3**: 95. 1912).

last week in June nor later than the last week in October. Its vegetative period, therefore, is about four months in this locality. Early in the summer of 1911 I started some cultures in small aquaria in the laboratory. These have now been under observation for seven months and have provided a valuable check on the field observations.

As shown in the accompanying figures, the mature plant occurs as 1-celled individuals, and as 2, 4, and 8-celled families. The 1-celled mature individual (fig. 5) is comparatively rare; it is spherical in form and may or may not retain parts of the outer gelatinous covering of the resting cell (figs. 1 and 3). The diameter of the outer wall averages 35 μ and of the cell 25 μ. The chromatophore is globose, parietal, comparatively thick, and may or may not contain a pyrenoid. In young cells the chromatophore is finely granular, in mature ones it is usually gorged with starch. The nucleus is centrally placed.

The 2-celled families are abundant and exhibit a great variety of forms. Some of these variations are shown in the figures. The mother cell wall may be nearly smooth and lenticular in form, or may be partially covered with a gelatinous secretion, or rarely may consist of two distinct layers, of which the inner one may be folded at the poles so that when viewed from the side it shows three ridges at either end (fig. 24). Except for the outermost wall, this last form closely resembles those from Australia. At the poles there are usually small "caps" formed of a tough gelatinous secretion. These appear to be secreted after the loss of the gelatinous covering of the resting stage. STOCKMAYER seems to have believed them to be on the inside of the mother wall, since he speaks of their fusion with the "bands" in the formation of the 4-celled families. I have not seen any specimens, however, in which this is the case.

The "caps" are regularly external to the mother wall and the "bands" are regularly internal. An appearance of an external band is sometimes made as in fig. 6, in which an equatorial ring of the gelatinous secretion, which surrounded the aplanospore wall during the rest period, remains.

The 2-celled families are 40–70 μ in length, 22–40 μ in breadth, and 20–30 μ in thickness. The cells are spherical, or depressed

globose, sometimes flattened on the inner side, and sometimes on the outer. Between the two cells there is usually a gray, brown, or black band (figs. 8 and 9) composed of a more or less tough granular gelatinous secretion. This substance is at first colorless (fig. 4) and darkens with age. The color is partly due to total refraction and partly to a pigment. When the band is absent the caps also are wanting (fig. 10), but the band may be present without the caps. The mother cell wall is retained until late maturity, that is, until a short time (probably one or two weeks) before the breaking up of the family. In some cases this implies an existence during three or four months, and for those most favorably situated for development about a month.

My earliest outdoor record for the late maturity and aplanospore stage (figs. 17 and 18) is July 21. The disappearance of the mother wall is probably coincident with a rather rapid increase in the diameter of the vegetative cells from an average of 20 μ to an average of 30 μ. The cells remain attached to the band for a short period, but finally break away from this by their continued enlargement also. This last separation is clearly not due to the gelatinization of either cell wall or the band as stated by most authors. This is shown by the fact that after separation the band usually exhibits a ragged transparent edge, or occasionally there remains attached to it a thin wall from which the cell has escaped by tearing along the line of juncture with the bands. At the time of separation the cells may be thick or thin-walled, and may have divided internally (fig. 18). The thin-walled aplanospores germinate very soon by enlarging and dividing. The thick-walled aplanospores secrete a further gelatinous covering (fig. 1) and go through a rest period. Those cells which have already divided before separation may continue development (in the summer) or become thick-walled, secrete a gelatinous covering, and go into a rest period (in late autumn).

The 4-celled families are of two distinct types: (1) those having the cells in the same plane; (2) those in which the cells have a tetrahedral arrangement. In both the vegetative cells are similar to those of the 2-celled families. The 4-celled families with the cells in one plane (figs. 12 and 13) are about as abundant as the

2-celled families in this locality. They vary in form from circular-lenticular (fig. 15) to elliptical-lenticular (fig. 11); from those having plane walls (fig. 14) to those having marked polar flattenings with a central ridge (fig. 16); from those with thick bands and caps to those entirely lacking the gelatinous secretion. When seen from the flat side, the bands when present are cruciform. They lie well within the mother wall, but may extend some distance beyond the cells (fig. 12). In the late maturity stage the mother wall is lost and the cells enlarge until they rather than the bands become the conspicuous feature (fig. 19). The cells may then separate at once or divide internally before separation (fig. 23). After separation of the aplanospores development or rest period follows as described under the 2-celled families. The tetrahedral 4-celled family (fig. 20) differs in having a close-fitting mother wall, in the necessarily different arrangement of the bands, and in the absence of polar caps. The life history is probably the same as for the preceding forms.

The 8-celled families are exceedingly rare. Out of the hundreds of specimens of the plant which I have examined from the collections and cultures, not more than a score of this type have been found. Of these there have been two forms about equally abundant: (1) those having the 8 cells arranged in the form of a cube with an edge 35–50 μ long, and (2) those with the 8 cells grouped more or less irregularly. These latter have in one or two instances resembled a cube that has been compressed so that the upper and lower faces are the shape of a rhombus.

These 8-celled families have a close-fitting mother cell wall until late maturity, when they are held only by the gelatinous bands. STOCKMAYER predicted the possibility of 8-celled families on the basis of the caps in the 4-celled forms, but he evidently had in mind families with 8 cells in the same plane.

The most important result of the cultures, however, has been to show that the mature colonies do not divide, that is, the 2-celled mature colonies do not form 4-celled colonies directly. When the bands are once formed they are permanent structures. Whether the family shall be 1-celled, 2-celled, 4-celled, or 8-celled is determined by the number of divisions that take place within the aplano-

spore. I have found a number of cases where the divisions have taken place before the cell left the family, and before the heavy gelatinous outer covering was secreted (figs. 18 and 23). But it is probable that in most instances this division takes place after the resting period (fig. 2), for most of the aplanospores which I have examined showed no division and 1-celled mature individuals are comparatively rare.

That the propagative cells from 2-celled families do not necessarily form 2-celled families is shown in fig. 18, in which one of the cells has divided twice, the other but once. The development of the bands may be clearly understood from fig. 4. After germination (fig. 3) begins, the cells assume a more and more spherical form. Accompanying this process is the gradual separation of the cells and the secretion of the gelatinous layer from the adjacent cell walls.

My experience with *Gloeotaenium* both in the field and in cultures is thus far against the probability of zoospore production. The extreme localization of the collecting places in the ponds; the fact that it is most abundant on the bottom, and is brought to the surface only through the rising of other algae; and the fact that in the laboratory aquaria it is found only on the bottom, all point to the absence of swimming spores during the period I have had the plant under observation.

In the light of the above observations I should put the plant among the Scenedesmaceae near the genus *Oocystis*. The present description of the genus will require modification as follows:

Cells globose or variously flattened, solitary or united in families of 2, 4, or 8 cells, with wide and distinctly lamellate cell walls; the mother cell wall is frequently ornamented with folds and gelatinous disks opposite the cells; a dark-colored gelatinous layer usually extends between the cells of a family; chromatophore globose, with or without a pyrenoid. Reproduction by aplanospores and daughter cells.

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EXPLANATION OF PLATE III

FIG. 1.—Aplanospore showing gelatinous secretion outside the cellulose wall; from culture; this and succeeding figures are from camera drawings.

FIG. 2.—Embryonic family about to enter resting period; from Hodgen's pond October 28, 1911; cell wall in optical section showing lamellae.

FIG. 3.—Germinating aplanospore; from culture.

FIG. 4.—Embryonic family showing early stage in the process of "band" formation; from Big Four pond July 10, 1911.

FIG. 5.—Mature one-celled individual; from Big Four pond July 10, 1911.

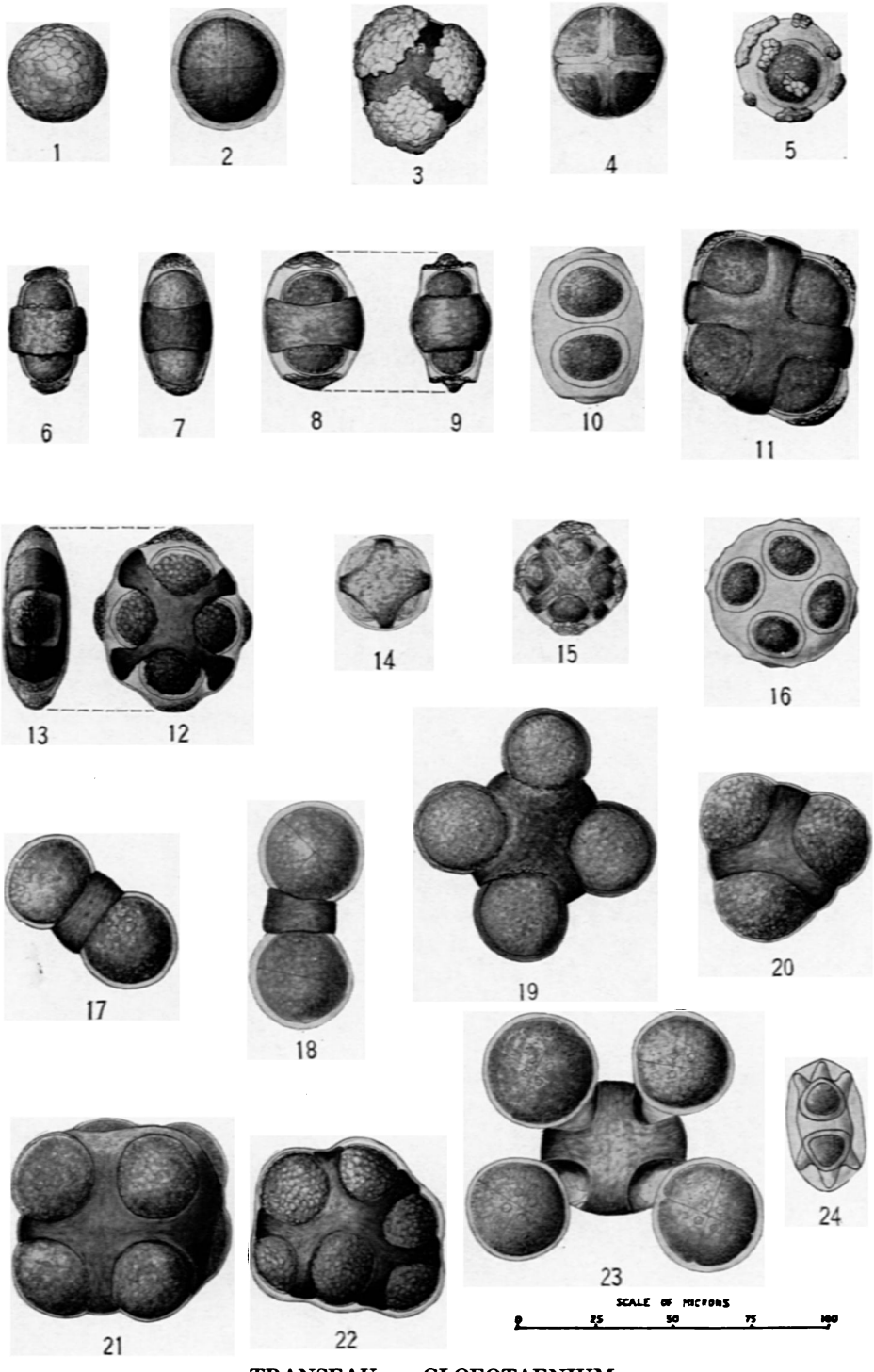
FIG. 6.—Two-celled family with equatorial remnant of gelatinous spore wall; from Hodgen's pond July 21, 1911.

FIG. 7.—Two-celled family showing band and caps; from Big Four pond July 10, 1911.

FIGS. 8 and 9.—Two-celled family, side and edge views, showing polar modification of the mother cell wall; from Big Four pond July 10, 1911.

FIG. 10.—Two-celled family lacking the gelatinous secretions; from Big Four pond July 10, 1911.

FIG. 11.—Four-celled family showing relation of bands and caps; from culture October 31, 1911.



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FIGS. 12 and 13.—Four-celled family, side and edge views; from Hodgen's pond September 20, 1911.

FIGS. 14 and 15.—Young four-celled families; from culture July 25, 1911.

FIG. 16.—Four-celled family without gelatinous secretions.

FIG. 17.—Mature two-celled family; from culture October 10, 1911.

FIG. 18.—Contents of aplanospores dividing before separation.

FIG. 19.—Mature four-celled family; from Hodgen's pond July 21, 1911.

FIG. 20.—Tetrahedral four-celled family; from Hodgen's pond July 21, 1911.

FIG. 21.—Cubical eight-celled family; from Big Four pond July 10, 1911.

FIG. 22.—Irregular eight-celled family; from culture October 28, 1911.

FIG. 23.—Cells of four-celled family in which division has preceded separation; from culture October 28, 1911.

FIG. 24.—Double-walled two-celled family; from Big Four pond July 10, 1911.